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HEMI-SYNC®
RECOVERING THE ATTRACTORS

by Glenn Pearce

Glenn Pearce, professor of philosophy, completed undergraduate work at William and Mary and graduate studies at Duke University. He has been a member of the faculty of the University of Western Ontario for twenty-four years and served as chairman of the philosophy department. His main interests are cognitive science and metaphysics. This presentation discusses preliminary results from the application of chaos theory mathematics to Hemi-Sync and brainwave frequencies.

My research on the encephalography of conscious states has three main goals:

1. Since the EEG data I am studying pertain to subjects exposed to Hemi-Sync® signals, there is some chance of providing feedback for the further development of Hemi-Sync technology.
2. By studying the cerebral activity underlying conscious states, one may hope to gain insight into the laws governing cognitive phenomena. Of course, what we can discover in this way depends crucially on the nature of the relation between neural behavior and states of consciousness.
3. This brings me to my long-range interest, which is philosophical, namely: to increase our basic understanding of the mind-brain relation itself. As noted by Henri Bergson almost a century ago, this relation has been *studied* very little. There are many theories, to be sure, but not much in the way of *testable* hypotheses. Thus, contrary to tradition, the study of human EEG records seems a very natural way to address this perennial question. Before describing my current work, a brief summary of the chaos-theoretic approach involved will be useful.

The behavior of a dynamic system may be represented in *phase* space, a multidimensional mathematical space with one dimension for each variable needed to describe the system. Each point in this space represents a possible state (“phase”) of the system; a *trajectory* through this space represents the possible behavior of the system over time; and an *attractor* for the system exists when nearby trajectories are drawn into a given one. For example, a pendulum is representable in two dimensions, for *position and momentum*. If it is free-swinging (so that it slows down and stops due to friction) its “phase portrait” spirals in to the central fixed point, which is its attractor. If it has a regular period (as when driven by a motor) then its phase portrait coincides with the attractor, which is a closed loop.

A system is *chaotic* when the dimension of its phase space is *fractal* (fractional); its attractor is said to be *strange*. Strange attractors never cross themselves or repeat—that would mean a periodic system—yet the behavior they describe is nonrandom. (By contrast, the portrait of truly random activity would visit every point in an infinite dimensional space.) Many strange attractors have become familiar; one of the best known is the attractor for the Lorenz weather model. *[Ed.: For more background information on chaos theory, see HEMI-SYNC JOURNAL, Fall 1990, Vol. VIII, No. 4.] [see: Topics/Perceptual Studies/Consciousness]*

One can computer-generate a system's attractor from its governing equations, if they are known. If not, we must somehow reconstruct the attractor for the system's behavior. The application of chaos theory to natural systems has been greatly advanced in the last decade by the development of accurate and reliable reconstruction methods, using time-series data from a single variable of the system. One such—the method of delays—is used in my current work, to which I now turn.

The investigation is motivated by the following questions: Are there neural attractors characteristic of specific cognitive processes or conscious states (e.g., TMI focus levels)? Are any (such) attractors correlated with specific Hemi-Sync signals? What implications would affirmative answers have for the prospect of controlled access to specific conscious states, and for the development of Hemi-Sync-related technologies?

I began to address these questions in February of 1991, when I was able to spend a week in the TMI lab, examining files from the NRS-24 brain mapping system. Subsequently, I have been constructing and studying two-dimensional phase portraits from EEG data on three subjects: RO (a sleep study); WR (a *GATEWAY* learning protocol study); and DM (unknown stimulus; short files used only for comparison). The same techniques were also applied to Hemi-Sync signals passed through the NRS-24 system without the intervention of a human brain.

Initially, it was unclear how to select from the enormous database available. However, since my first task was to master techniques new to me, it seemed reasonable to search for "typical" epochs, i.e., those which resemble averaged data. Following are a few of the preliminary results which have emerged, along with some highly tentative commentary.

There is a generic shape similarity among all the phase portraits from a given subject, regardless of stimulus differences, though there are many variations within the general pattern. On the other hand, there was general *dis*similarity of portrait shape between subjects.

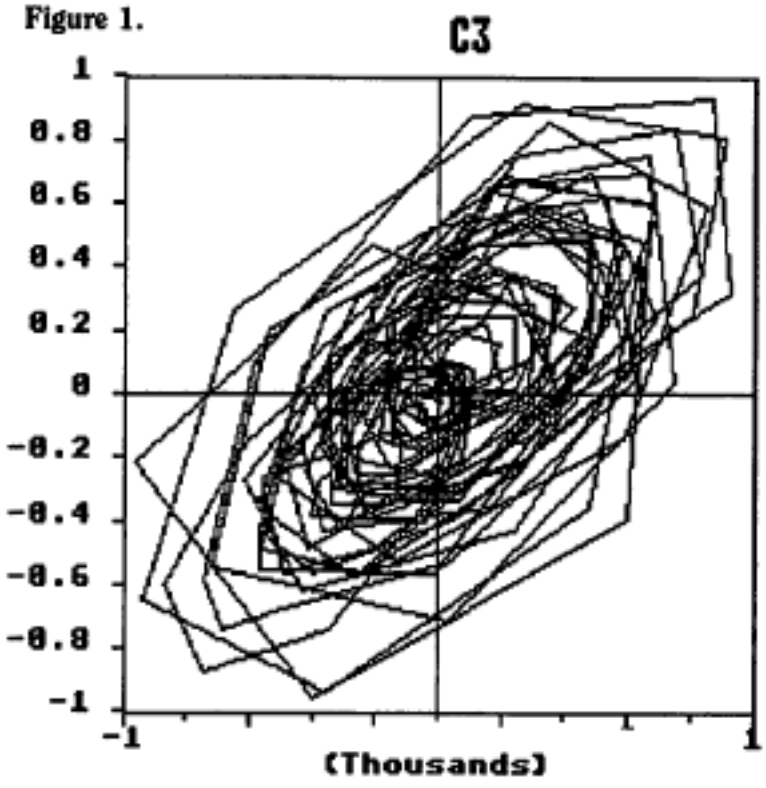
These two results suggest something like a neural handwriting or signature for each subject. (To confirm this conjecture would require a controlled multisubject study.) The existence of a *personal* signature need not preclude attractors characteristic of specific *cognitive* states; that depends on particular features of the attractors involved. This question is important in that

animal studies have suggested that there are such characteristic attractors (underlying odor recognition, for example) which might be generically similar across subjects.

Different electrode sites were examined in the case of subject RO, than in that of subject WR. Could this difference account for the signature differences observed? Apparently not, since a large block of WR data is from the site where the WR signature is maintained. Indeed, if portrait shapes were site specific, one would not expect the similarities found between two sites of the RO data.

There were several examples of rather dramatic similarity between the portraits of two sites for the same epoch in the RO data (Figure 1). Since these sites are on opposite sides of the head, hemispheric synchronization is strongly suggested. This can be confirmed by superimposing the raw EEG records, noting the high degree of overlap (Figure 2).

Figure 1.


C3
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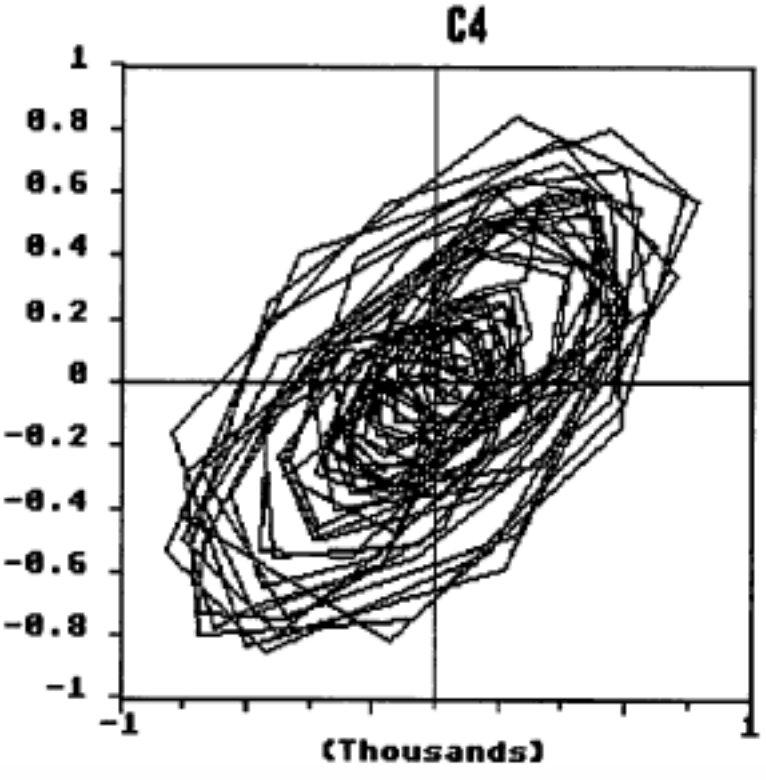
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1
1
(Thousands)


C4
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1
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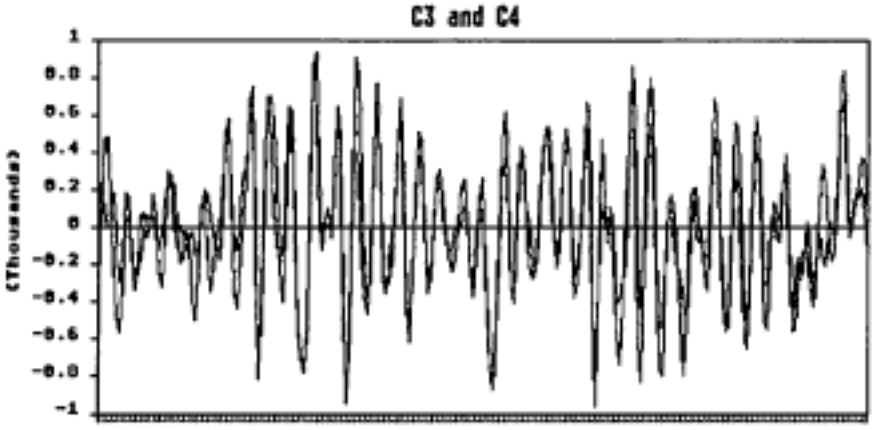
(Thousands)

Figure 2.



Such apparent synchronization might have resulted from head-movement artifacts, which affect all sites similarly and are strong enough to swamp the normally weaker brain waves. However, this explanation is easily rejected by inspecting adjacent epochs.

Another possible explanation is that the apparent synchronization is due to entrainment. This would be exciting if true, since it is the basic presupposition of the Hemi-Sync technology. In order to test this hypothesis directly, one would need *simultaneous* EEG and Hemi-Sync stimulus records, making it possible to investigate realtime correlations. Unfortunately, this was not part of the brain mapping protocol. In any case, that explanation is ruled out for examples of synchrony in the RO file which occur in the baseline epochs, when there is no auditory stimulus at all.

Yet another hypothesis might be suggested. Hemispheric synchrony is known to be correlated with certain relaxed states, quite independently of external stimuli, as was amply demonstrated by the TMI research report of Mohammad Sadigh in 1990. *[See HEMI-SYNC JOURNAL, Fall 1990, Vol. VIII, No. 4.] [See: Topics/Physiology/Brain Mapping]* Perhaps subject RO is simply *adept* at reaching such states? There may well be some evidence for this, though it would have required the subject's permission to report it here. Whatever the explanation, it is noteworthy that the portraits in question bear an interesting resemblance to the Focus 15 Hemi- Sync signal pattern, which is certainly consistent with the correlation between hemispheric synchrony and relaxed states.

This interim report only scratches the surface. I look forward to working more closely with TMI lab personnel over the coming months, and to reporting more fully at the 1992 Professional Seminar.